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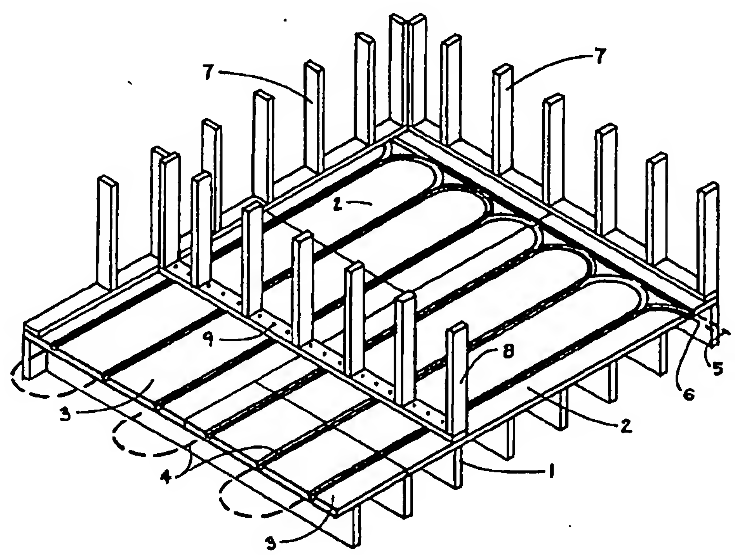

(57) Abstract

The present invention provides in combination, a radiant panel heating system, configured for ease of installation and maintenance which also provides the structural characteristics required of a subflooring panel within a floor framing system. The system consists of structural subflooring panels (2) with grooves arrayed in a modular geometry. The panels are overlaid with a heat-conducting surface embossed with a matching groove pattern. The panels are capable of being fastened to a variety of floor support structures (1) in a manner typical of subfloor panels, which fulfill a structural requirement only while simultaneously interacting to create an array of approximately evenly spaced grooves into which tubing (4) or wire of the type used in hydronic or electric radiant panel heating is installed.

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DESCRIPTION

FLOOR HEATING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to hydronic or electric radiant panel heating or cooling systems.

2. Description of the Prior Art

Prior art in the concept of heating a space by heating the floor surface within the space goes back as far as the Roman Empire. Hydronic floor panel heating systems currently in use employ metal or plastic tubing embedded in a concrete slab or tubing with aluminum plates attached through various means. There are systems (for example, as distributed by the Wirsbo Company of Apple Valley, Minnesota) where, after a floor is constructed, the aluminum plates are attached underneath the plywood subfloor, between the floor joists. There have been systems were the aluminum plates and tubing are supported by light framing (see for example Shiroki, US patent number 4,865,120), grooved foam plastic sheets or grooved plywood (for example as distributed by Lagerstedt and Krantz AB of Sweden) placed above the subfloor and covered by an additional sheet of nailable material. There have been some foam plastic systems (for example as distributed by Wirsbo AB of Sweden) and some tile systems (See for example German patent number DE3411339A1 and Williams, US patent number 3,037,746) that utilize modular groove geometry to facilitate the layout of the arrays of tubing.

There have been a number of systems that are comprised of individual panels which contain tubing already embedded in the panels and which are then joined together to create a larger radiant panel array (see for example Rapp, US patent number 2,681,796 and Japanese patent numbers 57-108531, 59-158919, 59-95321, 59-225228) which is placed upon a previously constructed subfloor system.

There is no evidence of systems where there is a combination of a structural subfloor panel, with a top surface comprised of a heat conductive sheet embossed with grooves laid out in a modular geometry, which implements the full range of features described herein. It is this unique combination of elements into a system which greatly simplifies the installation of radiant panel heating that distinguishes the present invention from the prior art.

All radiant panel heating systems have tended to provide superior comfort among other benefits and yet current systems have had mixed acceptance in part because of:

(A) Excessive Cost. Prior systems typically involve highly customized designs to fit each building design and as a result are largely site built. They often require additional structural design and cost due to the weight of the panels. Their installation is labor intensive and is accomplished by specialists. These systems disrupt the timing of the construction process and often interfere with the easy installation of finish floor materials.

(B) Reliability. In most current systems the tubing is concealed from the installers of finish floor materials and it is not unusual for a tube to be damaged by a fastener during this process. During a remodel, relocating interior walls also poses a great risk of tubing damage. When tubes are damaged the location of the damage may not be readily detected and the repairs often require substantial dismantling of the floor panels.

(C) Response time. Because of high thermal mass and/or high thermal resistance, current systems are typically slow to respond to changing heating loads with response times measured in hours or days.

OBJECTIVES AND ADVANTAGES

Accordingly the objectives of this invention are to provide for:

(1) A modular geometry, subfloor system, installed using conventional construction methods, timing and skills, which in one step provides a structural subfloor and the basis of a heating system.

(2) Reduced dead weight for a radiant panel heating system which will reduce lateral and vertical loading of a building's structural systems.

(3) A system which allows for and therefore is largely independent of wall placement and application of finish floor materials, is not easily damaged either during the primary construction or any subsequent remodeling phase and which is more readily repaired if damaged.

(4) A reduction in response time to changing heating loads.

(5) In combination with all of the above objectives: a reduction in the cost of materials and labor along with an increase in user satisfaction sufficient to make the overall cost/benefit comparison of radiant panel heating to other heating systems, more favorable.

SUMMARY OF INVENTION

The objectives of this invention are achieved as follows:

In a typical embodiment of the invention, the subflooring membrane of a building is constructed of special sub-floor panels made typically of plywood, oriented strand board or other structurally suitable material which like plywood is easily sawn, nailed, glued and otherwise utilized in a manner consistent with prevalent practices in the construction industry. The sub-floor panels have been manufactured with a pattern of grooves formed into their surface; a heat conductive sheet has been embossed to match the pattern of the grooves; and this sheet has been bonded to the sub-floor panels.

After the panels are in place, an elastomeric compound is placed in the grooves and tubing is pressed into the grooves, following the pattern provided by the modular geometry. The compound holds the tubes in place; fills in any air voids between the tubing and the heat conductive surface and is trowelled flush with the top surface of the panels thereby providing a smooth surface to which finish floor materials are easily attached. The heat conducting surface is in direct contact with the finish floor covering and provides for a more rapid thermal response than conventional systems.

In one step, prior to walls being constructed, the structural subfloor and heating system is installed, thereby providing great cost savings. The clear visibility of the tubing paths makes damage of the tubing while fastening walls and finish flooring materials to this subfloor, unlikely. In the event of damage, leaks are easily located and repairs are easily made.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully comprehended from the following detailed description and accompanying drawings in which:

FIG. 1 is an isometric view of this invention utilized within a typical floor framing, subfloor and wall framing system.

FIG. 2 is a schematic top view of the modular assembly of the heating panels into an array which provides a continuous unjointed tubing path.

FIG. 3 is a top view of the grooves in a typical modular sub-floor panel used for the end tubing runs.

FIG. 4 is a top view of the grooves in a typical modular sub-floor panel used for straight tubing runs.

FIG. 5 is a cross section view of the assembled sub-floor panel, heat conductive surface and hydronic tubing.

FIG. 6 is a top view of the grooves in a single modular sub-floor panel which is an aggregate of the geometries depicted in Figs. 3&4.

FIG. 7 is a top view of the grooves in a group of related modular sub-floor panels, which are disaggregated from the geometries of Figs. 3&4.

DETAILED DESCRIPTION

Referring now to Fig. 1, a typical application of the present invention within a floor framing system is depicted. Conventional floor joists **1** comprise the support system. Panels **2** (such as are depicted in Fig. 3) and **3** (such as are depicted in Fig. 4) are fastened to the floor joists in a manner typical of conventional subflooring membranes. A tube **4** of the type employed in radiant panel heating is pressed into the modular pathway of grooves.

In this example, the inlet is at **5** and the outlet is at **6**. The spacing of the grooves allows for exterior walls **7** to be fastened directly to the panels without damaging the tubes. Interior walls **8** can cross the grooves without bearing on and therefore without damaging the tubes. The clear visibility of the tubing paths allows for walls or finish floor materials to be fastened to the subfloor membrane with nails **9**, without damage to the tubes.

If repairs become necessary, the same visibility that makes punctures unlikely will make leaks easy to locate. Only that part of the finish floor covering over the defect would have to be removed rather than removing whole sections of the subfloor.

The heat conductive surface is in direct contact with the floor covering such as for example carpet, hardwood floor or tile. The thermal impedance provided by the finish floor covering slows down heat dissipation from the surface sufficiently to reduce the heat gradient between adjacent hydronic tube elements.

In existing hydronic systems the warm up time or thermal lag is governed by the thermal mass and/or resistance of the concrete slab or the plywood subfloor. This can be many hours or even days in existing systems. In the subject invention, low mass plus low resistance permits a change of surface temperature to become measurable in minutes.

Fig. 2 is a top view of a typical array of heating panels which shows an example of how hydronic tubing is placed in an array. The hot water input **5** is routed along the grooves **10** tangential to the arcs of end section panels **2**. Then it is routed to a 90 degree curved groove **11**. It is then routed as shown in Fig. 2 through end panels **2** turning 180 degrees **12** typically at each end panel, and through straight panels **3** finally turning in a 90 degree groove **11** to the output **6** thereby completing a circuit.

Fig. 3 is a top view of an end section panel utilizing three longitudinal grooves per panel. The size and aspect ratio is typical of subfloor panels currently in use. The spacing between the centers of three grooves **13, 14, 15** is one third of the width of the panel. The centers of grooves **13** and **15** are spaced one sixth of the width of the panel **2** from the long edge of the panel **2**. On one end of the panel **2** the ends of grooves **13, 14** and **15** are Terminated by semi circular arc grooves **12**. In addition, grooves **13, 15** connect to quarter arc circular grooves **11**. Lastly a straight groove **10** is placed tangential and connecting to arcs **11** and **12**. The center of this tangential groove is spaced the same distance from the short edge of a panel as grooves **13** and **15** are spaced from long edge.

This spacing, which is based on three primary tubing paths per panel, is optimum for typical construction in the U.S. based on English units of measure. It allows for the erection of exterior walls of conventional thickness while providing sufficient space between the interior surface of an exterior wall and the nearest tubing path for attachment of carpet tack strips. Nonetheless, it may be advantageous to manufacture panels with one, two, four, five or six tube modules per sheet of subfloor, but still in accord generally with the geometry and modularity depicted herein. These units may be selected where, for example, ease of carpet installation is less important than various other considerations such as surface temperature and tubing density. Where metric based lumber and subflooring materials are used, the exact spacing may need to be modified based on the metric sizing of conventional construction materials, but still in accord with the geometry and modularity depicted herein.

Fig. 4 is a top view of a straight section panel utilizing three longitudinal grooves per panel. The spacing between the centers of the three grooves **16, 17, 18** is one third of the width of the panel **3**. The centers of grooves **16** and **18** are spaced one sixth of the width of the panel from the long edge of the panel **3**. The variations arising from differing numbers of tubing pathways per panel or metric units of measure envisioned in the description of the panels in Fig. 3 apply to these straight run panels as well.

Fig. 5 is a cross section view applicable to all panels depicted herein. A groove **19** is formed in a sub-floor panel. In one embodiment, panels may be manufactured of a homogenous material such as plywood or oriented strand board. In that embodiment, the layer of a panel **23** in which the groove is formed is structurally compromised by the groove

and therefore the remaining layer **24** which is ungrooved must have sufficient structural characteristics to span the typical spacing of floor joists **1** found in standard construction. Alternatively, the most cost effective embodiment of this invention may be a hybrid panel with a layer **23** of a material such as chip board or particle board whose primary characteristics are compressive strength and a layer **24** of a material such as plywood or oriented strand board whose characteristics are optimized for structure across a span.

A heat conducting sheet **20** is pre-formed to have a contour matching the sub-floor panel topography and is then bonded to the panel. After installation of the panels in the array of FIG. 1 & 2, elastomer **21** is placed into groove **19**. Then the hydronic tubing **22** is pushed tightly into the bottom of the elastomer lined groove **19** to make good thermal contact with the heat conducting surface **20**. Any elastomer **21** not filling voids between the heat conductive surface of groove **19** and the hydronic tubing **22** will be squeezed to the top of the hydronic tubing **22**. This excess is then trowelled flush with the top surface of the panel. This provides a flat surface on which floor covering can be installed directly.

The elastomer **21** serves three functions. It improves the heat transfer between the hydronic tubing **5** and the conductive surface **20** by reducing or eliminating air filled voids. It provides a smooth surface and support for pliable floor coverings such as carpet, linoleum or tile. It holds the tubing in place. In the case of a rigid floor covering such as hardwood, a tight press fit between the hydronic tubing **22** and the heat conductive lined groove **19** may permit complete omission of the elastomer **21** and may be the economically most attractive construction method.

The two panel types depicted in Figs. 3&4 are sufficient to produce all of the desired benefits envisioned for this invention with only occasional on site modification. However, in order to allow just two types of panels to accommodate a wide variety of panel layouts, it is obvious that in a given panel there may be arced paths **11** and **12** and tangential paths **10** that are not utilized in a given panel. Eliminating these unused paths by disaggregating the basic geometry of the system into a number of differentiated panels might reduce some of the costs of manufacture and installation with the trade off that more types of panels may be required thereby increasing the tooling and inventory costs associated with this invention. Figs. 7a, 7b, 7c, 7d, 7e depict an example of a system of panels which is a disaggregation of the geometries of panels **2** and **3**.

Alternatively, cost savings due to simplified manufacturing and stocking requirements, may override any need to reduce the number of unused paths and may, to the contrary, dictate that a single panel which aggregates the geometry of the panels depicted in Figs. 3&4 will be most cost effective. Fig. 6 is an example of single panel which is an aggregation of the geometries of panels **2** and **3** into a single panel.

The invention has other potential applications and those skilled in the art can find other fields of use. The present invention may be utilized as a wall panel or ceiling panel which can be easily be made smooth in a manner typical of Gypsum Board surfaces. Instead of heating, the invention could be used for cooling by circulating a cooling liquid. In another example electric panel heating may use a similar modular panel with smaller grooves to receive the smaller diameter wires typical of these systems. Electric cooling could be accomplished by using coulomb cooling. There may be other electronic or thermodynamic applications where standardized modular panels can facilitate the easy assembly of arrays of wires, tubes or fibers as part of a conductive surface.

CLAIMS

What is claimed is:

1. A system of heating or cooling elements comprised of structural panels which have a multiplicity of grooves and a heat conducting layer, embossed to approximately match the grooves and adhered to the surface of the panels; wherein the grooves are laid out in a modular geometry that facilitates the joining together of these panels in varied configurations which will provide continuous groove pathways; wherein a hollow tube is embedded in the groove pathways through which a thermal energy transfer medium is circulated thereby providing a method of heating or cooling the panel surface.

2. The system of heating or cooling elements according to claim one wherein the geometry is based on two panel designs; wherein one panel design has only approximately parallel and evenly space grooves; wherein the second panel design has evenly spaced parallel grooves as in the first panel design but which are terminated in arced grooves and which has an additional groove which runs at 90 degrees to the parallel grooves and this additional groove is tangent to the arced grooves; wherein this geometry allows the assembly of arrays of tubing which can run in parallel paths which at the ends of their runs can turn back on themselves in a 180 degree change in direction or alternately which can run at 90 degrees to the primary tubing direction in order to travel across the array; wherein the result of this system is an approximately evenly spaced circuit of tubing that causes the heat conducting surface to be raised or lowered to an approximately even temperature.

3. The system of heating or cooling elements according to claim two, wherein the geometries of the two panels are aggregated into a single panel.

4. The system of heating or cooling elements according to claim two, wherein the geometries of the two panels are disaggregated into a greater number of panels each with a unique groove pattern.

5. The terminating panel according to claim two wherein there is no groove running at 90 degrees to the primary tubing paths and tangential to the half or quarter arcs, wherein the circuit of the tubing path is completed outside the panel surface in a manner which does not require that the tubing travel across the array in the plane of the other tubing.

6. The system of heating or cooling elements according to claim one wherein the structural substrate from which the panels are manufactured is any typical subflooring material such as plywood, oriented strand board, chip board or other suitable material which can be utilized in a manner typical of subflooring within a floor framing system, into which grooves may be machined, stamped, molded or otherwise formed while maintaining the panel's ability to bridge the spans typical of wood framed construction.

7. The system of floor heating or cooling elements according to claim six; wherein the substrate is a hybrid of materials; wherein there is an ungrooved layer which has the structural characteristics which will allow it to bridge the spans typical of framed construction, which is then overlaid with a layer of a material whose structural characteristics are sufficient compressive strength and surface hardness to allow wall framing or finish floor materials to be fastened directly to it and into which the modular grooves are easily formed by machining, molding, pressing or other efficient means.

8. The system of floor heating elements according to claim two wherein the arcs are a geometric shape which while not circular, nonetheless, has the ability to change the direction of the tubing paths by approximately 90 degrees or approximately 180 degrees.

9. The system of floor heating elements according to claim one wherein the visibility and spacing of the tubing paths allows wall structures or finish floor materials to be fastened to the floor membrane, without damaging the tubes; wherein in the event of damage to a tube it is readily repaired.

10. The system of floor heating elements according to claim one wherein the space between the hollow tube and the thermally conducting layer contains a self hardening filler material to eliminate any insulating effects of an air gap or which also can be trowelled flush with the top surface so as to provide a substantially smooth surface or which can hold the tubing in place within the groove.

11. The system of floor heating elements according to claim ten wherein the filler material contains means for improving its heat conductive properties.

12. The system of floor heating elements according to claim one wherein instead of a tube there is a wire and the means for thermal energy transfer utilizes ohmic heating.

13. The system of floor cooling elements according to claim thirteen wherein the means for thermal energy transfer utilizes coulomb cooling.

14. The system of floor heating elements according to claim one wherein there exists a separate and independent structural floor system and the panel's structural qualities are limited to sufficient compressive strength and surface hardness to allow wall framing or finish floor materials to be fastened directly to it.

15. The system according to claim one, wherein the panels are composed of a suitable material for the finished surface of a ceiling which is then heated or cooled.

16. The system according to claim one, wherein the panels are composed of a suitable material for the finished surface of a wall which is then heated or cooled.

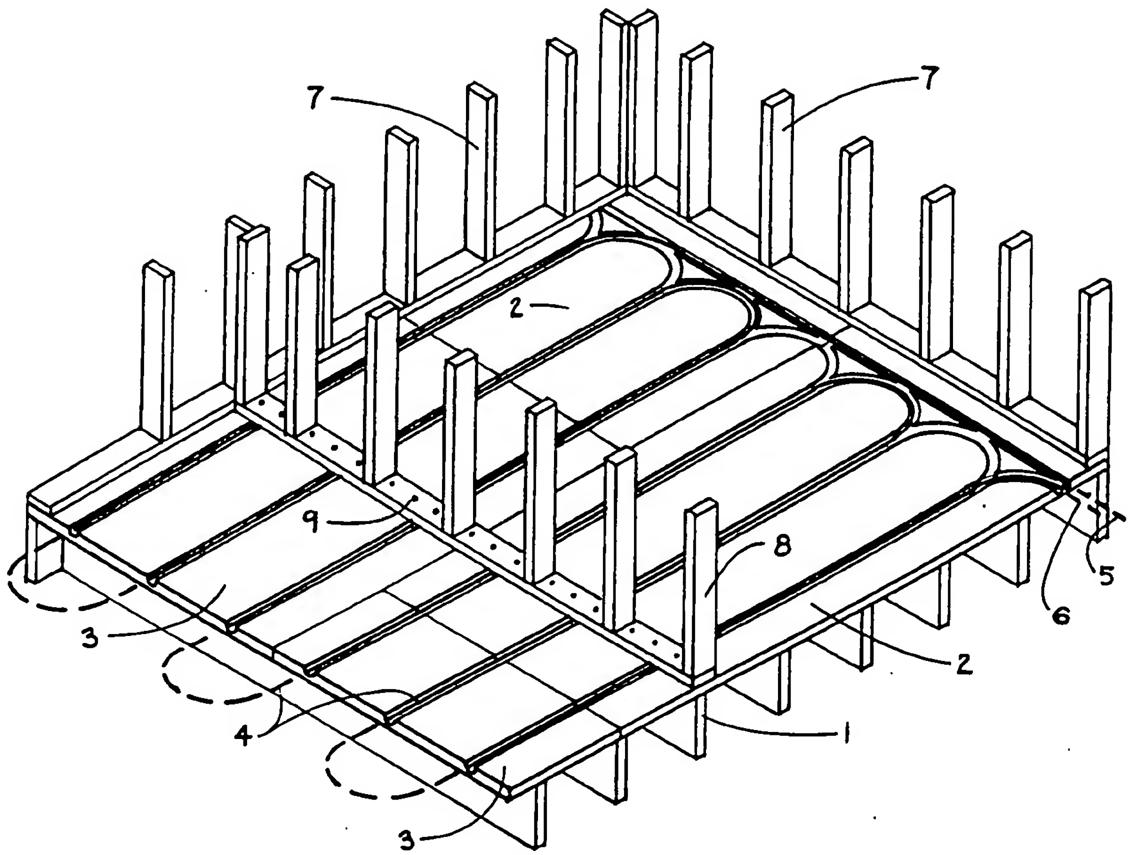

FIG. 1

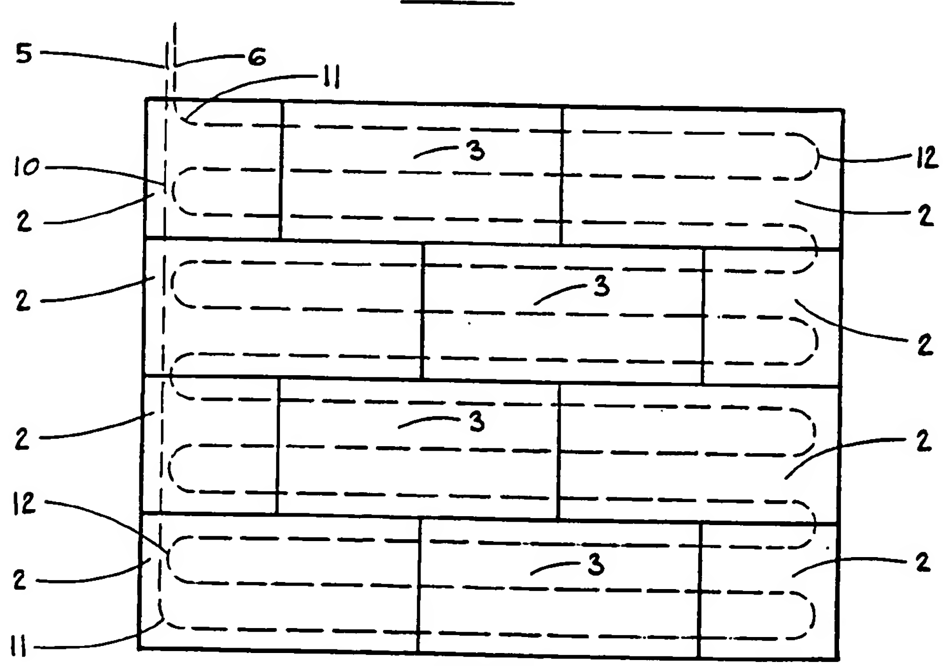

FIG. 2

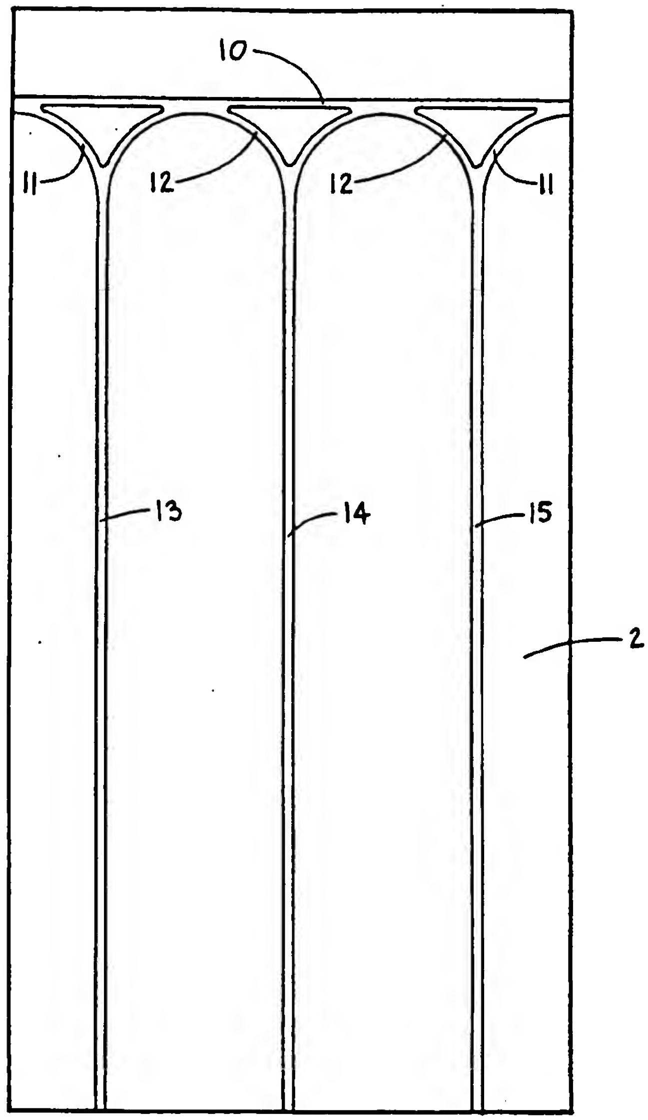

FIG. 3

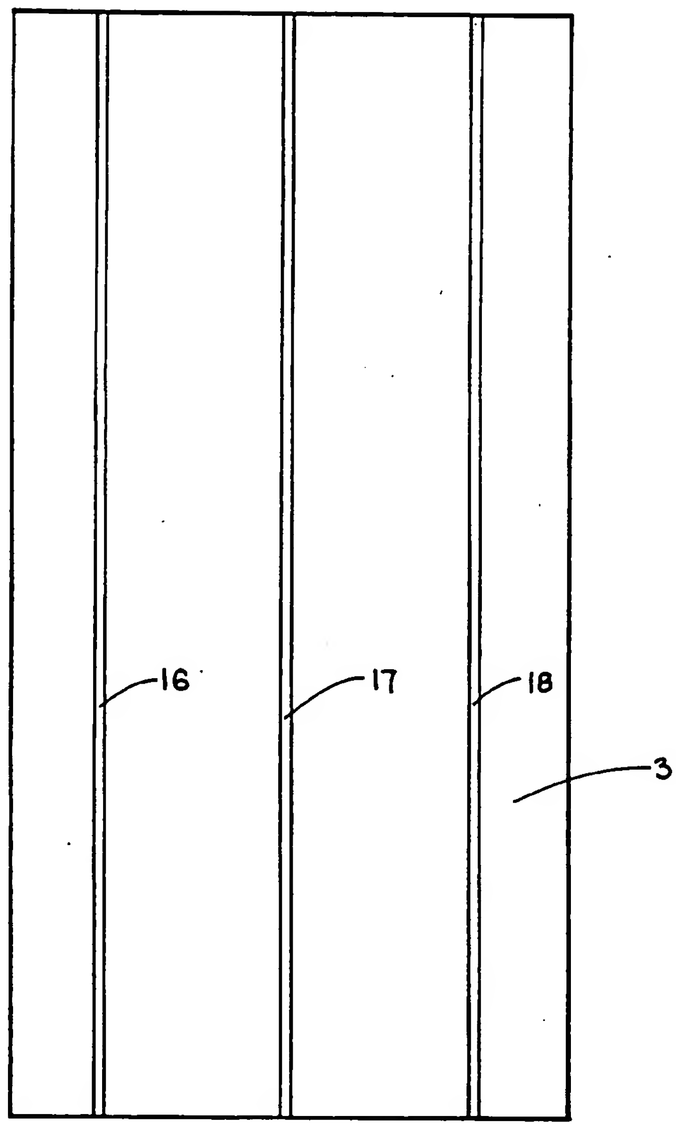

FIG. 4

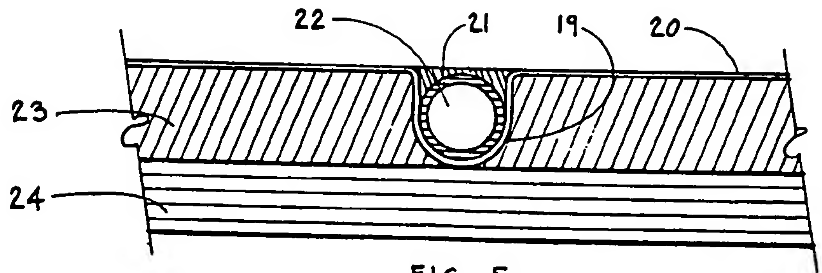

FIG. 5

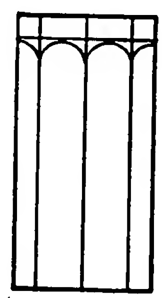

FIG. 6

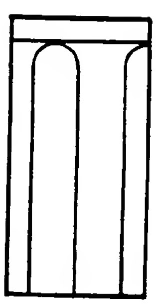

FIG. 7A

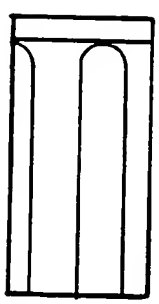

FIG. 7B

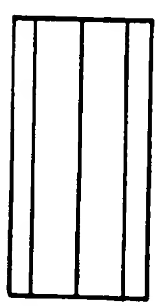

FIG. 7C

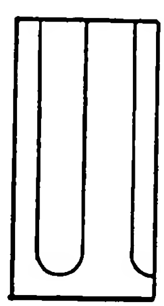

FIG. 7D

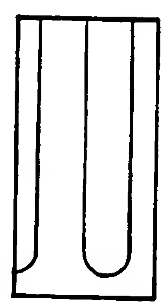

FIG. 7E

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/03461

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :F24D 3/14, 3/12
US CL :237/69
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 237/69; 165/49, 56; 52/220.5; 428/131, 137, 164

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS search terms: floor(p)heat?(p)groove

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,865,120 (SHIROKI) 12 September 1989, Figure 3, col. 1, lines 7-30.	1-16
Y	US, A, 5,292,065 (FIEDRICH) 08 March 1994, Figures 21 and 22, column 17, lines 5-50.	1-16
Y	US, A, 160,014 (GEDNEY) 23 February 1875, column 1, lines 5-20.	1-16
Y	US, A, 5,095,716 (YOU) 17 March 1992, Abstract.	13
Y	US, A, 5,022,459 (CHILES) 11 June 1991, Abstract.	12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 APRIL 1995	31 MAY 1995

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